Science and Technology in Brazil (1993)

Simon Schwartzman, Maria Helena Magalhães Castro

Contribution prepared for Hudson, R. A. (1998). Brazil a country study. Washington, DC, Federal Research Division, Library of Congress.

1. Introduction - Science outside the mainstream 1
2. Historical Evolution 4
4. University research and graduate education 22
Glossary 23
References 26

1. Introduction - Science outside the mainstream

Brazil, in the 1970s, undertook a major attempt to establish a strong scientific and technological basis, which would make the country self-sufficient in the economy, militarily powerful, and able to withstand international pressures and constraints. Heavy investments were made in the country's infrastructure for the production of steel, machine tools, energy, communications and transportation; a few high technology projects with expected civilian spin-offs were started, in atomic energy, aeronautics and space research; the university system was reformed along the American model of graduate education and departmental organization, and financing agencies for science and technology were set up and endowed with more resources than the existing demand for S&T projects. Several hundred graduate programs were organized, and several thousand fellowships begun to be awarded every year for studies in the best universities in the United States and Europe. This project attracted international attention, and was considered an example for many countries wishing to make the jump from underdevelopment, poverty and international dependency to economic growth, better standards of living for their population, and

self-reliance. This project lost its impetus during the eighties, however, as Brazil went from being one of the world's fastest growing developing economies to a protracted period of stagnation. The investments in science and technology of the previous years were not enough to ward off the forthcoming crisis of international debt and uncontrolled inflation, and became, in many instances, just an additional financial burden for a state that lost, in a few years, most of its management capabilities and available resources. The question for the nineties is what went wrong, and how the pool of competence created in those years can be best utilized to bring the country back to a pattern of economic growth and continuously improving social conditions, in a profoundly transformed international context.

The crisis in the eighties resulted from a combination of factors, including the exhaustion of the previous pattern of inward growth through import substitution, raising international interest rates and oil prices, and the uncontrolled increase in public expenditures, due to political fragmentation and extensive patronage. It cannot be explained by eventual errors in Science and Technology alone, and could not be redressed just by better science and technology policies. However, a closer examination of this experience is very illuminating about some of the central weaknesses and strengths of Brazil.

Modern science and technology is a product of Western culture and tradition, and is not easily transposed to other societies and cultures. The examples of Japan, Korea and Taiwan show that this transposition is not impossible, and can make them even more effective than in their cultures of origin. The comparison between Brazil and the Asian countries point to important differences in the two experiences, and possible explanations for the outcome.

Science and Technology in Western Europe, and more recently in the United States, has developed along two parallel and mutual reinforcing lines: as part of a broader scientific culture, linked to education, the development of modern professions and a growing and prestigious scientific community; and as part of the increasingly effectiveness of the industrial and military establishments (Ben-David 1971). The terms "science" is usually applied to the fist, while "technology" is used for the latter, and the assumption has been always that they are two sides of the same coin.

The Asian countries, however, followed a strikingly different path. They introduced modern technology, but little of modern science in their universities and other similar institutions;

and most of their investments in technology took place in industrial firms, rather than in large, isolated governmental agencies, including the military sector. Brazil, in contrast, developed most of its scientific capabilities in the universities, while investments in technology went to a few, large-scale government projects under the military, and to a handful of state-owned corporations.

The assumption in Brazil was that science and technology would eventually spill over from higher education and sophisticated technological projects into society as a whole. In practice, the introduction of scientific research and graduate education in universities happened in a time of rapid expansion of higher education enrollment, leading to declining quality in average. The consequence was that, while a handful of universities and departments reached levels of quality similar to those in the developed countries, most of the higher education institutions, private and public, lagged behind (Schwartzman 1991b). In technology, the large military-based projects in atomic energy, space research and aeronautics helped in the development of a few, highly qualified network of local suppliers and partners, but did not enhance the quality and competence of the industrial system as a whole (Cavagnari Filho 1994). In the early eighties, the policies of technological nationalism and self-sufficiency had narrowed to the computer sector, where a fiercely protective legislation tried to shield the Brazilian mini and microcomputer industries from foreign competition. Here again, the policy allowed for the growth of local industry and a few well qualified firms, but the effect of the productive capabilities of the economy as a whole was negative, and the inability to follow rapid changes in price and quality in the international market forced the policy to be shut down (Tigre, 1993). There are other features found in the Asian countries which did not exist in Brazil, and help to understand the different outcomes of the country's development drives: the generalization of basic and secondary education at an early stage, leading to a competent and well educated manpower basis; lower levels of social inequality, strengthening the internal market for local products; a sustained effort toward international competitiveness, requiring high levels of industrial efficiency and quality control; and competent and powerful public bureaucracies, working in close association with a small number of large, well-endowed private firms.

2. Historical Evolution

A brief historical sketch is necessary to understand how the current Brazilian R&D institutions and culture were shaped. In very broad terms, it is possible to divide this history in the following periods:

a) *Colonial science*, covering the period from the discovery of Brazil by the Portuguese until the beginnings of the nineteenth century. Contrary to what happened in many regions of Spanish American, the Portuguese did not bring their universities to the new world, and whatever existed in terms of scientific research in those years was done by European explorers, which brought their finds to the European collections of Natural History, and incorporated them in their expanding understanding of the world. Economic activities in those years were restricted to the production of sugar, gold and coffee; slave labor existed almost to the end of the nineteenth century, and work tended to be labor and land extensive, and unqualified.

b) *Imperial Science*, going from 1808 (when the seat of the Portuguese Crown moves to Rio de Janeiro, due to the Napoleonic wars) until the beginning of the Republican period in 1889. The first higher education schools were created in first years (a military academy in Rio de Janeiro, two medical and two law schools), and a small number of research institutions started to appear. The search for new mineral riches and the effort to adapt agriculture products known in Europe and other regions to Brazil led to the creation of the first botanical gardens and mineralogical collections.

Brazil became formally independent in 1822, and between 1840 and 1889 the country went through a period of political stability under the reign of Pedro II. New scientific institutions are created in those years, such as the museums of natural history, the astronomical observatory and the Imperial Geological Commission (Comissão Geológica Imperial). Foreign scientists are invited to head these institutions, and Pedro II himself was very active not only in the creation of Brazilian institutions, but also in supporting science in Europe. The kind of research developed in those years is still closer to Europe than to the country, and is not subject to the same standards of quality and competence of its European model. The main economic activity in Brazil was the

production of coffee for the international market, based on slave labor. After the 1850's, European and Japanese immigrants gradually replaced slave labor, and an internal market for food, textiles and other basic products started to develop.

c) Applied science in agriculture and health. This period covers the first decades of the Republic, from 1889 to the mid thirties. With the Republic, Brazil becomes more decentralized, and the country's economic pole shifts gradually to São Paulo, the center of coffee production and the destination of massive European immigration, second only to Buenos Aires in Latin America. Most of the new higher education and research institutions in those years were created in São Paulo, and were addressed to the two main areas of concern in those years: public health, and particularly the sanitation of the country's main port cities, Santos and Rio de Janeiro; and agricultural research. The main Paulista institutions from those years are the Agronomic Institute of Campinas (Instituto Agronômico de Campinas), the Biological Institute for Animal Protection (Instituto Biológico de Defesa Animal), the Butantan Institute for snake venom research (Instituto Butantan), São Paulo's Geological Commission (Comissão Geológica do Estado de São Paulo) and the Vaccine Institute (Instituto Vacinogênico). This is also the period when the liberal professions expand, and tried to find their place in the modernization of Brazilian society (Schwartzman 1991a).

The most significant scientific institution in the period, however, is the Instituto Manguinhos (now the Fundação Instituto Oswaldo Cruz in Rio de Janeiro). This institute was subordinated to the health authorities, and played a central role in the control of tropical diseases, such as the yellow fever, malaria and parasitic diseases. It developed important research lines in fields like helminthology and entomology, and its researchers were able to identify the full etiology of the Chagas disease. Manguinhos was the link between Brazilian researchers and the international scientific community, and the place where most of Brazil's leading figures in human biology, public health and related fields were trained. Manguinhos' success story is attributed to the ability of its leadership to combine a clear sense of short-term relevance to a commitment with the values of scholarship and research (Stepan 1976).

d) *The search for alternatives: the 1930s.* The 1930s are a period of political centralization and the first attempt to provide Brazil with modern administrative, military and educational institutions. The main initiatives are the following:

- The University of São Paulo (Universidade de São Paulo - USP) was created in 1934 as the country's first. Its nucleus was to be a Faculty of Philosophy, Sciences and Letters, with professors coming from France, Italy, Germany and other European countries; it brought together also several research and higher education institutions in the state, such as the medical, engineering and law schools (Faculdade de Medicina, Escola Politécnica and Faculdade de Direito), and became, to this day, Brazil's main academic and research institution. A national university was created in Rio de Janeiro in 1939 along the same pattern (the Universidade do Brasil, today the Universidade Federal do Rio de Janeiro - UFRJ), and the model was later generalized for the rest of the country. Except for USP, however, and a few sectors at UFRJ, the Faculties of Philosophy worked as teacher colleges, with little or no research, while the traditional professional schools remained independent and geared to their traditional degree-granting activities. Behind similar structures, there were deep conceptual differences between the Universidade de São Paulo and the Universidade do Brasil, which help to understand the reasons for the different outcomes. USP was created by the São Paulo elites as part of an emerging tradition of cultural enlightenment, while the Universidade do Brasil was to be the product of an authoritarian government, under the direct influence of the conservative Catholic Church. A third university was created in Rio de Janeiro in 1935, the University of the Federal District (Universidade do Distrito Federal - UDF), in a spirit similar to USP's, but it was closed down by the federal government a few years later (Schwartzman, Bomeny e Costa 2000).

- The first institutions for technological research were created in those years, the National Institute for Technology (Instituto Nacional de Tecnologia - INT) in Rio de Janeiro and the Institute for Technological Research (Instituto de Pesquisas

Tecnológicas - IPT) in São Paulo. They were supposed to provide technical support to an emerging national industry, and INT was active in the first studies for the utilization of sugar-cane alcohol of engine combustion and of coal from Santa Catarina in steel industry.

- Economic nationalism becomes dominant by the end of the decade. The 1934 Code of Mines declares government's property all richness under the soil; the first steel plant, the National Steel Industry (Companhia Siderúrgica Nacional) is established in Volta Redonda in 1942, with American support and linked to Brazil's entrance in the Second World War; oil exploration becomes a state monopoly, with restrictions to foreign and national private interests.
- As the federal administration gets more centralized and bureaucratized, some of its research institutions suffer. The Instituto Oswaldo Cruz goes through one of its more serious crisis, for lack of autonomy and support, while INT gradually turns into an agency for certifications in behalf of the public bureaucracy (Schwartzman e Castro 1985)).

e).*"Science and technology as modernization" (1945-1964).* The understanding after the Second World War was that Brazil was becoming a modern, industrial society, and that science and technology were to be one important ingredient in this trend. This was to take place through the generalization of higher education and the organization of scientists and researchers to increase their public visibility and influence.

Two diverging patterns were already taking shape in the development of science, technology and higher education in Brazil, in rough correspondence with the broad cleavage in Brazilian society between the economic and political centers of São Paulo and Rio de Janeiro; the first more associative, with strong civilian institutions and entrepreneurial, and the second more hierarchical, relying on the civilian and military bureaucracies, and linking with the country's poorer regions through patronage.

São Paulo had already the country's main university, and after the World War the region's scientists organized two leading institutions, the Brazilian Association for the Advancement of Science (Sociedade Brasileira para o Progresso da Ciência, SBPC) and the São Paulo Foundation

for Science Support (Fundação de Amparo à Pesquisa de São Paulo, FAPESP). SBPC became Brazil's main voluntary association for Brazilian academics, and has been very influential in raising the scientist's voice on behalf of issues of national and more technical nature, from the protection intellectual freedom in the years of military regime to the in favor of the national computer industry or regarding patent legislation. FAPESP receives about 1% of the state tax revenues, and was organized as a very efficient and respected grant-giving agency, running according to strict peer review procedures. Besides USP, FAPESP, IPT and SBPC, the state of São Paulo had in the nineties 16 other research institutes linked to different branches of the state administration, one research oriented university, Campinas (Universidade de Campinas - UNICAMP), and a state-wide university geared to professional education, the Universidade do Estado de São Paulo – UNESP.

The national government, meanwhile, embarked on its first attempt to muster the power of atomic energy, through the combined creation of the National Research Council (Conselho Nacional de Pesquisas, presently the National Council for Scientific and Technological Development, Conselho Nacional de Desenvolvimento Científico e Tecnológico, which kept the traditional acronym, CNPq), together with the National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear, CNEN), and the Brazilian Institute for Physics Research (Instituto Brasileiro de Pesquisas Físicas - CBPF). Together, these three institutions were supposed to develop the full cycle from the production of nuclear fuel to its application in energy generation, and eventually the technology of atomic weaponry. Beleaguered by limited resources, lack of qualified leadership and international pressures, the atomic energy project was abandoned in practice with the end of the Getúlio Vargas government in 1954. CNPq was turned into a small, underfunded grant-giving agency, while the IBPF became an academic research center that was later absorbed by CNPq as one of its institutes, after CNPq's reform in the 1970's.

Interestingly enough, one of the most successful projects of the fifties, the Air Force Technological Institute (Instituto Tecnológico da Aeronáutica, ITA), was placed on the city of São José dos Campos, between Rio de Janeiro and São Paulo. ITA was organized by the Brazilian air force with the support of the American government, working in close association with the Massachusetts Institute of Technology, but was not restricted to military students and subjects. It became Brazil's leading engineering school, recruiting students from all over the country, who

went to occupy central positions in Brazil's industry, research institutions and main S&T agencies. ITA's research branch, the Air Force Technological Center (Centro Tecnológico da Aeronáutica - CTA) became the basis for Brazil's airplane industry, and made of São José dos Campos the hub of Brazil's more sophisticated technological industries. What was unique with ITA was this combination of strong government support, qualified institutional leadership and its civilian orientation, which gave it the ability to tap some of the best talent among the country's researchers and students. With the military governments after 1964, ITA gradually lost its autonomy and civilian character, and entered a period of decline.

f) "The great leap forward" (1968-1980). These are the years when the Brazilian military government, which took power in 1964, embarked on its ambitious project of scientific and technological self-sufficiency. In the first years, the military government entered in conflict with a significant part of the country's scientific leadership, because of their real or assumed socialist and anti-American stands. Later, however, they were to reconcile, based on their shared nationalism and concern with social and economic development. This project reached its climax during the years of Ernesto Geisel's presidency, 1975-1979. These are the main projects and initiatives in this period:

- The university reform in 1969, with the introduction of graduate education and, the end of the traditional "chair" system and the organization of universities in departments and institutes.

- Science and technology became institutionally linked with the economic authorities, and new support agencies and programs were created by the federal government, under a newly created Planning Ministry (Ministério do Planejamento, MINIPLAN, at times the Planning Secretariat, Secretaria de Planejamento, SEPLAN).

- -The National Bank for Economic Development (now the Banco Nacional de Desenvolvimento Econômico e Social, BNDES), Brazil's main investment bank, created a special fund for science and technology, which gave rise to a new agency,

the Financing Agency for Studies and Projects (Financiadora de Estudos e Projetos - FINEP). FINEP was organized as a private corporation under ministerial supervision, and was responsible for the administration of a national fund for scientific and technological development (Fundo Nacional de Desenvolvimento Científico e Tecnológico - FNDCT) for institutional grants and the ability to loan resources for technological projects in the private sector. FNDCT yearly budget in the mid-seventies was around US $ 200 million dollars, being gradually reduced to about US $ 40 million by the early nineties.

- The establishment of two large research and graduate institutions in science and technology, the Coordination of Graduate Programs in Engineering at UFRJ (Coordenação dos Programas de Pós-Graduação em Engenharia da Universidade Federal do Rio de Janeiro, COPPE) and the University of Campinas, geared to research and training in advanced engineering (chemical, mechanical, biomedical, electric, metallurgic, nuclear, navel) and new technologies derived from recent advances in solid state physics and lasers. Other institutions also benefitted, such as the Technological Center of the Catholic University and Rio de Janeiro (Pontifícia Universidade Católica do Rio de Janeiro, PUC), the Escola Politécnica at USP and ITA.
- The cooperation agreement with Germany for the development of in nuclear technology, followed by the development of the so-called "nuclear parallel program";
- The beginning of the Space Program, with the development launching vehicles and satellite;
- The development of the subsonic military jet aircraft (the AMX project, in association with Italy);
- The policy of market reserve for the computer industry
- The writing of three successive National Plans for Scientific and Technological Development;
- The creation of research centers within the country's main state-owned corporations, such as Petrobrás (oil), Telebrás (communications), Vale do Rio Doce (mining) and others.

- The reorganization and strengthening of a national system for agriculture research, through the Brazilian Company for Agricultural Research (Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA), under the Ministry of Agriculture.

On the positive side, these initiatives were characterized by abundant resources, quick decision mechanisms, and flexibility in the use of the grants. Even for large projects, resources were provided whenever possible to the group leader, in a deliberate bypass of the traditional, cumbersome and ineffectual procedures of public administration. On the other hand, the absence of well defined peer review procedures, particularly at FINEP, allowed for the support of less than worthy groups and projects, which became permanent clients of FNDCT resources.

More serious was the dissociation which existed between the policies for science and technology, geared toward self-sufficiency and a strong presence of the public sector in the economy, and the economic policies of the same period, open to the entrance of multi-national corporations and the acquisition of ready-made, turn-key technologies from abroad. The consequence is that the eventual products of research seldom benefitted the productive sector, except in the field of agriculture, and in a few associations between state-owned corporations and universities. Only for computers did the government try to link research and production, under the umbrella of market reserve. This policy, however, took shape when the period of economic expansion of the seventies had already expired, and no systematic investments were made in computer sciences and technology to try to complete this link.

g) The S&T sector as a pressure group (1980-1990). In this last period, which starts with the beginning of the last military presidency of João Figueiredo and includes the first civilian government of José Sarney, the picture changes completely. The planning and economic ministries are unified, the science and technology sector loses its privileged access to the higher echelons; no resources are available to correspond to the increasing expectations of the previous years; scientists, engineers and public employees in the S&T sector become one among many different interest groups competing for resources from a government concerned only with its political survival and the administration of a mounting inflation and external debt. In those years, what, what the scientists obtained from one hand were taken out with the other:

- The "informatics" policy, developed in the previous years, was signed by President Figueiredo on the last days of his mandate, but the items in the legislation creating the resources for R&D in computer science were vetoed. Restrictions to the entrance of foreign technology were enforced, but no significant technology was generated inside the country, Brazil lagged behind other countries in the use of computers and electronic equipment for its industries and services.

- The José Sarney government created a new Ministry of Science and Technology (Ministério da Ciência e Tecnologia - MCT), which was given, at the beginning, to a person associated with the nationalist ideologies and perceptions of the past. For a while, the new Minister was able to raise the budget for the science and technology sector. However, he remained isolated within the government, had no influence on policy making for the economy, and inflation brought the S&T budget to extremely low levels.

- With the new Ministry, the bureaucracy in the Science and Technology agencies increased in size, and lost its former flexibility. The S&T agencies became much more sensitive to patronage politics than before; and most of the resources of CNPq were diverted to fellowship programs, without clear procedures of quality control, and no mechanisms to make the fellows active in the country S&T institutions.
- New actors entered in the dispute for resources and control of the country's agencies of science, technology and higher education: political parties and groups, unionized university professors and employees in the universities and public agencies, scientific societies, special interest groups within the scientific and technological community. SBPC lost its image as a semi-detached association of scientists, and became an active lobbyist for more public resources and the protection of national technology from international competition.
- A sector loan for science and technology was approved by the World Bank in 1985 for US 72 million dollars (with another 107 million to be provided by the Brazilian government) to increase the country's competence in selected areas of science and technology, under the assumption that the government would maintain the historical levels of expenditures for the sector as a whole. This expectation was not fulfilled,

the World Bank's program became one of the few sources of support for scientific research, without playing its expected role of contributing directly to the improvement of Brazil's industrial competitiveness (Stemmer 1995)

h) Science for industrial competitiveness (after 1990)

The years of Fernando Collor de Melo presidency were market by the declared intention making science and technology more directly relevant to industrial effectiveness, in a an economy which was being deregulated and submitted to international competition. It was also a period of high inflation, economic depression and political crisis. Some of the main initiatives and proposals of those years, some dating from the previous years, were:

- The continuation of the World Bank sector loan to science and technology, which was renewed in 1991;
- The transformation of FINEP into an agency concerned almost exclusively with loans for the development of industrial technology, and the sharp reduction in the FNDCT;
- The end of the market reserve for the Brazilian computer industry;
- Severe restrictions in the resources available for CNPq, which became restricted to the administration of fellowships;
- Proposals to create strong links between universities and the productive sector, through "technological parks" other mechanisms of university-industry cooperation;
- Closing down, "phasing out" or revision of the large military projects such as the parallel nuclear program and the space program.
- Privatization of most public-owned corporations.

While several measures related to the opening of Brazil's economy were implemented, and are still in effect, little was achieved in terms of turning the S&T sector into toward new directions. No incentives existed for the new roles and functions to be tried out, economic depression limited industrial investments to the bare minimum for survival, and the scientific community looked at the Collor government with mistrust.

At the time of this writing, in mid 1993, the Itamar Franco government, which succeeded Fernando Collor after his impeachment, has been still unable to overcome the country's run-away inflation, and did not have the chance to device a science and technology policy on its own. The Minister of Science and Technology, José Israel Vargas, is an internationally respected physicist, has high credibility in Brazil, and has been working to keep the issues of science technology high in the government agenda, to pass legislation creating incentives for technology investments in industry, to proceed with Brazil's space program, and to assure the bare minimum of resources for the daily activities of the government's main S&T agencies. No long-term policy, however, seem to exist.

3. The Administration of Science and Technology in Brazil.

a. *The National Research Council (CNPq).* The main agency for science and technology in Brazil is the Ministry of Science and Technology, which includes the National Research Council, CNPq and FINEP as its two main agencies. CNPq is a complex structure with about 2,500 employees which runs an extensive lines of fellowships and research grants, and a number of special programs, such as the "National Program for Human Resource Development for Technological Development" (Programa Nacional de Capacitação de Recursos Humanos para o Desenvolvimento Tecnológico - RHAE) and the Program for Competitiveness and Technological Diffusion (Programa de Apoio à Competitividade e Difusão Tecnológica - PCDT), and integrated programs such as Endemic Diseases, Virology, Genetics, Agricultural Development, Humid and Semi-Arid Tropical Regions and others. Fellowships and research grants are provided under peer review evaluations, while most of the resources for the special programs, when available, are managed directly the Council's administration. CNPq has also a number of research institutes of its own, the Brazilian Center for Physics Research (Centro Brasileiro de Pesquisas Físicas, CBPF), the Center for Mineral Technology (Centro de Tecnologia Mineral - CETEM), the Brazilian Institute for Scientific and Technological Information (Instituto Brasileiro de Informação Científica e Tecnológica - IBICT), the Institute

for Pure and Applied Mathematics (Instituto de Matemática Pura e Aplicada - IMPA), the National Observatory (Observatório Nacional - ON), the National Astrophysics Laboratory (Laboratório Nacional de Astrofísica, LNA), the Museum of Astronomy and related Sciences (Museu de Astronomia e Ciências Afins, MAST), the Museu Paraense Emílio Goeldi - MPEG, the National Computer Science Laboratory (Laboratório Nacional de Computação Científica - LNCC) and the National Laboratory of Sincrotron Light (Laboratório Nacional de Luz Síncrotron, LNLS). These institutes vary in quality and size, and many of them have their own graduate education programs. The President and directors of CNPq are indicated by the Minister of Science and Technology, and a 20 member Conselho Deliberativo, with a strong presence of scientists, is supposed to supervise it.

The activities of CNPq are formally divided into fellowships and grants ("ações de fomento"), research ("execução de pesquisas") and information and diffusion activities. In 1990 CNPq spent about 350 million dollars in all its activities, and 371 million in 1991. About 70% of the total is used for "fomento", 10% for research (the management of CNPq's own institutes) and the remaining 20% for administrative and other expenses. From "fomento", 81% of it goes into fellowships. Table 1 shows that most of the fellowships are given to undergraduate and M. A. students, which is a reflection of the limited demand that exists for advanced degrees.

Table 1. CNPq, number of fellowships granted, 1990	in Brasil	Abroad	Total
undergraduate (iniciação científica)	5,887	---	5,887
graduate, non degree (aperfeiçoamento)	2,389	---	2,389
M.A.students (mestrado)	8,661	89	8,750
doctoral students	2,637	923	3,560
Post-doctoral fellowships	45	373	418

training (estágios)	---	80	80
Salary supplement for faculty and full-time researchers (bolsas de pesquisa)	3,594	---	3,594
TOTAL	23,213	1,465	24,678

b. FINEP. The second main agency for the federal government is the Financing Agency for Studies and Projects, The President and Directors of the other agency, FINEP, are also indicated by the Minister, but there are no mechanisms for the presence of outside reviewers and supervisors. FINEP has traditionally worked along two different lines, one in the administration of the National Fund for Scientific and Technological Development, FNDCT, which provided grants to R&D public and non-profit institutions; and the other as a specialized bank making loans to the private sector for technological development and innovation projects.

Table 2. FINEP, signed contracts, 1991	quantity	Value in US$ 1,000	percentage	average value in US$ 1,000
a) Loans	52	14.832,17	13,31	285,23
to Industry (ADTEN - Programa de Apoio ao Desenvolvimento Tecnológico da Indústria Nacional)	50	13.391,78	12,01	267,84
to Consulting firms (AUSC - Programa de Apoio aos Usuários de Serviços de Consultoria)	2	1.440,39	1,29	720,19
b) Grants (FNDCT - Fundo Nacional de Desenvolvimento Científico e Tecnológico)	378	56.602,50	50,78	149,74
c) Grants - World Bank Sector Loan (PADCT - Programa de Apoio ao Desenvolvimento Científico e Tecnológico)	264	40.037,49	35,92	151,66

Total	694	111.472,16	100,00	160,62

c. Other sectors of MCT. Besides CNPq and FINEP, the Ministry of Science and Technology has a few other institutions under its direct supervision, such as the Instituto Nacional de Pesquisas da Amazônia - IMPA, the Instituto Nacional de Pesquisas Espaciais - INPE and the Instituto Nacional de Tecnologia - INT). The Ministry is also is responsible for the National Council for Informatics (Conselho Nacional de Informática - CONIN) which decides how, among other things, on tax exemptions for technological investments in industry, and participates in the drafting and negotiation with Congress of legislation relevant to the S&T sector, regarding patents, fiscal incentives, tariffs, environment control, and so forth.

d. CAPES. Outside the Ministry of Science and Technology, the main agency is the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES (Coordination for High Level Manpower Training), at the Ministry of Education. CAPES provides fellowships for graduate education in Brazil and abroad, and has run for several years a peer-reviewed evaluation system for the country's graduate programs. The fellowship program is divided in two parts, one which responding to the spontaneous demand reaching its offices ("demanda social") and the other directed to the improvement of faculty in Federal Universities (Progama Integrado de Capacitação de Docentes - PICD). Table 3 provides an overview of CAPES fellowship programs.

Table 3 - CAPES, fellowships granted in 1990	In Brazil (spontaneous demand)	In Brazil (PICD)	abroad)
undergraduate (iniciação científica)	889		---
graduate, non-degree (especialização)	---	11	82
masters' degree	9,255	1,549	199
doctoral degree	1,609	1,835	1141
post-doctoral	---		114
"sandwich"* programs, M. A. level	---		16
"sandwich" programs, Ph.D. level	---		101
For retired professors (dedicação acadêmica)	289		

other	---		103
Total	12,042	3,95	1,756
* "Sandwich" fellowships are those given for students in graduate programs in Brazil to spend a year or similar period in a foreign institution.			
Source: CAPES, Relatório de Atividades 1990 e 1991.			

e. Other federal activities. Together, CNPq. CAPES and FINEP are responsible for the administration of the World Bank supported PADCT program, under the coordination of the Ministry of Science and Technology. Table 4 shows that, on average, the agencies under the Ministry of Science and Technology, do not handle more than a third of the country's total S&T federal budget, with another third going to projects in the military sector. Another major agency is EMBRAPA, which has a budget equivalent to that of CNPq, and is run by the Ministry of Agriculture. The traditional Instituto Oswaldo Cruz in Rio de Janeiro remains an important research institution in public health and related fields.

Table 4. Budgets of Brazil's main agencies for Science and Technology, 1980-1988 (percentages)					
YEAR	1980	1982	1984	1986	1988
a) Financing agencies for research and education					
CNPq	17.74	10.69	11.43	8.53	17.18
CAPES	1.89	2.62	2.99	3.33	8.18
Ministry of Science and Technology				10.20	10.82
Federal Universities	5.66	8.38	7.53	7.93	5.53
Subtotal (%)	**25.28**	**21.69**	**21.95**	**30.00**	**41.71**
Military sector					
Nacional Security Council		0.77	0.91	3.33	5.24
Joint Chiefs of Staff (Estado Maior das Forças Armadas)				4.73	4.29
Ministry of Aeronautics		0.31	0.13	0.87	1.88
INPE				2.47	2.82
CNEN	6.79	6.00	9.87	5.20	5.82
Ministry of Mines and Energy	1.70	27.46	11.95	9.60	3.88
Subtotal (%)	**8.49**	**34.54**	**22.86**	**26.20**	**23.94**
Sectorial Research institutions					
Agriculture: Embrapa+Embrater	22.08	20.69	24.68	14.13	17.59
Health: Instituto Oswaldo Cruz	1.89	1.23	1.30	0.80	1.94
Metrology: Instituto Nacional de Metrologia	3.96	2.15	0.78	1.07	1.59
Subtotal	**27.92**	**24.08**	**26.75**	**16.00**	**21.12**
Total (%)	61.70	80.31	71.56	72.20	86.76
Other expenditures (%)	38.30	19.69	28.44	27.80	13.24
Total in US $	530	1300	770	1500	1700

f. Science and technology in the states. There were about US $300 million dollars for science and technology in the budgets of the Brazilian states for 1991, about 40% of it from the state of São Paulo, and another 35% from the states of Minas Gerais, Rio de Janeiro, and Bahia. After 1988 most Brazilian states established in their constitutions a fixed amount of their budgets to be given to the science and technology sector. They followed the example of São Paulo, which provides FAPESP with about 1% of the state tax revenues, which, in 1991, amounted to about 60

million dollars. However, São Paulo is the only place where the constitutional rule is strictly followed.

g. The São Paulo S&T system. FAPESP is just one part of a large science, technology and higher education run by the State of São Paulo, which includes three public universities and several research institutes. These activities are coordinated by the state Secretary for Science, Technology and Economic Development (Secretaria de Ciência, Tecnologia e Desenvolvimento Econômico - SCTDE). Most of the institutions under SCTDE, however, are autonomous - the three universities, FAPESP and the Instituto de Pesquisas Tecnológicas. The Institute for Nuclear Research (Instituto de Pesquisas Nucleares - IPEN) is also formally linked to SCTDE, and is located on the campus of the Universidade de São Paulo, but is run, in practice, by the federal government. Besides FAPESP, SCTDE runs a state fund for scientific and technological development (Fundo Estadual de Desenvolvimento Científico e Tecnológico - FUNCET which provides loans for technology projects for the private sector, cooperatives and associations, in collaboration with São Paulo's State Bank (Banco do Estado de São Paulo - BANESPA), with a budget of about 20 million dollars; and a grants program through its Department of Science and Technology (Departamento de Ciência e Tecnologia - DCET). A global picture of the expenditures of the state of São Paulo in science and technology can be seen on table 5.

Table 5. Expenditures for Science and Technology in the State of São Paulo, 1992 (in US$ 1,000)	
DCET/FUNCET	22,500
FAPESP	70,000
Universities:	
Universidade de São Paulo	306,519
Universidade de Campinas	122,877
UNESP	143,728
	Institutes :
IPT	56,900

15 other institutes (except IPEN)	106,973
Source: Campanário and Serra, 1993.	

4. University research and graduate education

Most of Brazil's competence in research and development is located in its main public universities. There were about 1.5 million higher education students, around 10% of the age cohort, distributed in federal (21.1%), state (12.7%), municipal (5.1) and private institutions (61.2%). Only a fraction of the university professors hold a doctoral degree, and they are concentrated in the São Paulo state system and in some of the best federal universities (table 6). The São Paulo state system is also responsible for more than fifty percent of the doctoral degrees granted in the country.

Table 6. Education obtained by the higher education professorate.

	Federal institutions	**State institutions**	**Municipal institutions**	**Private institutions**	**Total**
no undergraduate degree	0.4%	0.1%	0.1%	0.3%	0.3%
undergraduate	29.3	33.7	40.5	37.1	34.0
graduate, no degree	23.4	17.7	47.8	42.9	32.0
masters' degree	30.4	21.8	8.9	14.5	21.0
doctoral degree	16.5	26.6	2.8	5.1	12.7
Total (100%)	43,397	22,556	4,142	57,934	128,029
M. A. Degrees granted (%)	61.9	27.5	---	10.6	100%
Doctoral Degrees granted	38.5	56.5	---	5.0	100%

Sources: Ministério da Educação, Serviço de Estatística da Educação e Cultura - SSEC, 1989; and

Ministério da Educação. CAPES.

Research in universities is usually associated with graduate education. Most academics in public institutions have full-time contracts, with salaries which equivalent to those obtained in the private market, plus the benefits of stability, long vacations and early retirement with full-time benefits. The assumption is that they should combine teaching with research, but, in practice, only a fraction has the necessary training for research work. The universities provide physical space and salaries for research, but little else; the researcher, or the research group, has to reach out for support money and research grants. In most of the cases the researcher applies for grants from CNPq and FAPESP, or to some private foundation in Brazil or abroad. Equipment and library holdings in the universities are usually obtained through special grants and projects from FINEP or from occasional programs run by the government, in some cases with resources from the World Bank or the Inter American Development Bank. They can enter also in projects of research cooperation with public and private corporations, or with the government itself. The Universidade Campinas, for instance, has had an important cooperation agreement with Telebrás, Brazil' s communications holding, and COPPE has worked with Petrobrás in the development of new technologies for deep sea oil drilling. The general rule is that even the best universities, such as USP, UNICAMP, Universidade Federal de São Carlos and Escola Paulista de Medicina, which are also the most research-intensive institutions, do not have resources in their regular budgets to keep their library holdings and scientific equipment up to date. The consequence is that the most entrepreneurial and competent departments and institutes are able to work according to fairly high standards of efficiency, with all the necessary equipment and supporting staff, while others, in the same institution, may not be able to get a micro-computer or to renew the subscription of a couple of journals.

Glossary

Universidade de São Paulo - USP
Instituto Nacional de Tecnologia - INT
Instituto de Pesquisas Tecnológicas - IPT
Sociedade Brasileira para o Progresso da Ciência, SBPC

Fundação de Amparo à Pesquisa de São Paulo, FAPESP

Universidade de Campinas - UNICAMP

Universidade do Estado de São Paulo - UNESP

Comissão Nacional de Energia Nuclear, CNEN

Instituto Brasileiro de Pesquisas Físicas - CBPF

Instituto Tecnológico da Aeronáutica, ITA

Centro Tecnológico da Aeronáutica - CTA

Ministério do Planejamento, MINIPLAN

Secretaria de Planejamento, SEPLAN

Banco Nacional de Desenvolvimento Econômico e Social, BNDES

Financiadora de Estudos e Projetos - FINEP

Fundo Nacional de Desenvolvimento Científico e Tecnológico - FNDCT

Coordenação dos Programas de Pós-Graduação em Engenharia da Universidade Federal do Rio de Janeiro, COPPE

Pontifícia Universidade Católica do Rio de Janeiro, PUC

Petrobrás

Telebrás

Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA

Ministério da Ciência e Tecnologia - MCT

Programa Nacional de Capacitação de Recursos Humanos para o Desenvolvimento Tecnológico - RHAE) and the Program

Programa de Apoio à Competitividade e Difusão Tecnológica - PCDT

Centro de Tecnologia Mineral - CETEM

Instituto Brasileiro de Informação Científica e Tecnológica - IBICT

Observatório Nacional - ON

Laboratório Nacional de Astrofísica, LNA

Museu de Astronomia e Ciências Afins, MAST

Museu Paraense Emílio Goeldi - MPEG

Laboratório Nacional de Computação Científica - LNCC

Laboratório Nacional de Luz Síncrotron, LNLS

ADTEN - Programa de Apoio ao Desenvolvimento Tecnológico da Indústria Nacional

AUSC - Programa de Apoio aos Usuários de Serviços de Consultoria

PADCT - Programa de Apoio ao Desenvolvimento Científico e Tecnológico

Instituto Nacional de Pesquisas da Amazônia - IMPA

Instituto Nacional de Pesquisas Espaciais - INPE

Progama Integrado de Capacitação de Docentes - PICD

Secretaria de Ciência, Tecnologia e Desenvolvimento Econômico - SCTDE

Fundo Estadual de Desenvolvimento Científico e Tecnológico - FUNCET

Banco do Estado de São Paulo - BANESPA

Departamento de Ciência e Tecnologia - DCET

Serviço de Estatística da Educação e Cultura – SSEC

References

Ben-David, Joseph. 1971. *The scientist's role in society a comparative study*. Englewood Cliffs, N.J.: Prentice Hall.

Cavagnari Filho, Geraldo Lesbat. 1994. "P&D Militar: Situação, Avaliação e Perspectivas." Pp. 321-255 in *Ciência e Tecnologia no Brasil (volume 3): a Capacitação Brasileira para a Pesquisa Científica e Tecnológica*, editado por Simon Schwartzman. Rio de Janeiro: Fundação Getúlio Vargas.

Schwartzman, Simon. 1991a. "Changing roles of new knowledge: research institutions and societal transformations in Brazil." Pp. 230-60 in *Social sciences and modern states national experiences and theoretical crossroads*, editado por Peter Wagner, Carol Hirschon Weiss, Bjorn Wittrock, e Hellmut Wollman. Cambridge England, New York: Cambridge University Press.

—. 1991b. *A space for science the development of the scientific community in Brazil*. University Park: Pennsylvania State University Press.

Schwartzman, Simon, Helena Maria Bousquet Bomeny, e Vanda Maria Ribeiro Costa. 2000. *Tempos de Capanema*. Rio de Janeiro: Paz e Terra / Fundação Getúlio Vargas.

Schwartzman, Simon, e Maria Helena Magalhães Castro. 1985. "Nacionalismo, iniciativa privada e o papel da pesquisa tecnológica no desenvolvimento industrial; os primórdios de um debate." *Dados - Revista de Ciências Sociais* 28(1):89 a 111.

Stemmer, Caspar Erich. 1995. "Programa de Apoio ao Desenvolvimento Científico e Tecnológico (PADCT)."

Stepan, Nancy. 1976. *Beginnings of Brazilian science Oswaldo Cruz, medical research and policy, 1890-1920*. New York: Science History Publications.